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Role of CT Angiography & Colour Flow Imaging (USG) in Evaluation of Peripheral Arterial Diseases

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Abstract: ***Purpose: To compare multidetector computed tomography (MDCT) angiography &colour flow imaging (USG)in evaluation of patients with peripheral arterialdiseases. Also evaluate the role MDCT in providing information regarding collateral circulation in peripheral arterial diseases and aiding treatment planning in peripheral arterial diseases. Material and methods: CT angiography performed with "Brilliance" 64 slice CT scanner by Philips on 50 patients with clinical diagnosis peripheral arterial diseases. The authors performed additional Doppler ultrasound examination. Result and Conclusion: When colour Doppler USG and MDCTA are compared, MDCTA detects more stenotic or occluded arteries in supra-popliteal, infrapopliteal, whole leg comparisons & excellent diagnostic performance. Colour Doppler USG is useful screening tool, however in symptomatic patient for detailed evaluation, MDCTA is a semi-invasive, fast, and accurate alternative to DSA, and we believe MDCTA better detects stenotic or obstructed arteries than colour flow imaging (USG) in patients of PAD.***

Keyword: Color Doppler, MDCT, stenosis, PVD, DSA

1. Introduction

Peripheral vascular disease (PVD) refers to diseases of blood vessels outside the heart and brain. It's often a narrowing of vessels that carry blood to the legs, arms, stomach or kidneys. It is a common vascular disorder with high incidence rates in the industrialized world and it contributes to significant morbidity and mortality[1]. Peripheral artery disease (PAD) is associated with a prevalence of 4 to 12 % in the adult population; present up to 20 % in elderly population (i.e. > 70 years old) [2]. Peripheral arterial disease is a marker of systemic atherosclerosis. Symptomatic PAD may be observed as estimated annual incidence of 26/10,000 in the male and 12/10,000 in the femalepopulation. The majority of patients with PAD have atherosclerotic disease of the lower extremity. The infrarenal abdominal aorta, the iliac arteries, the femoral arteries and the below the knee (BTK) arteries are among the most common sites of chronic obliterative atherosclerosis, accounting for up to 90% of all symptomatic PAD cases .Most of the patients suffer from a PAD of different degree, ranging from the typical intermittent claudication to the most severe critical limb ischemia (CLI). Accordingly, it is also estimated that at least three times more individuals are asymptomatic. Atherosclerotic PAD of the upper extremity is much less common, thus it will not be further discussed and excluded in the present manuscript [3]

The first medical approach in patients presenting with PAD, consists of screening for other associated cardiovascular, and the cerebrovascular pathologies. Secondarily an optimal medical management of the cardiovascular risk factors is essential with an attempt for healthy life-style modifications. Third and this especially for claudicant patients, walking exercises are necessary in order to improve walking capacity, thusqualityof life. Finally, in cases of severe life-limiting claudication or sign of critical limb ischemia, a revascularization procedure should be attempted.For this purpose, evaluation of peripheral vasculature is an integral part in the management of patients with peripheral vascular disease. Also polytrauma patients with suspected vascular injury and patients with bone and soft tissue tumors need to be evaluated further for better planning of treatment.

Until as recently as 10 years ago, catheter-directed conventional angiography and digital subtraction angiography were the only angiographic techniques that provided sufficient anatomical details to allow surgical planning for patients with peripheral vascular disease. However the complications by means of arterial puncture, the need for hospitalization, its high radiation dose, and potential nephrotoxicity secondary to iodinated contrast agents and patient discomfort associated with these techniques have prompted the need of less invasive means of assessing the lower extremity arterialsystem.There are several alternative imaging modalities to conventional angiography i.e. DSA, colour flow imaging (Colour flow imaging (USG)), computed tomographyangiography (CTA) and magnetic resonance angiography (MRA)[4], which play a crucial role in the management of patients with peripheral arterialdisease.Colour flow imaging ultrasonography (Colour flow imaging (USG)) is non-invasive but has shown some limitation due to interobserver variations & machine related parameters. Despite its wide use in patients with PAD, it has lower sensitivity than multi-detector computed tomographic (MDCT) angiography.[5].With advances in CT angiography, especially in the multidetector row technique MDCT, it is now possible scan larger body volumes within shorter time periods at high enough resolution to provide good delineation of arterial inflow and outflow.

2. Aims and objectives

- To compare multidetector computed tomography (MDCT) angiography&colour flow imaging (USG) in evaluation of patients with peripheral arterialdiseases.
- To evaluate the role of multidetector computed tomography (MDCT) in providing information regarding collateral circulation in peripheral arterial diseases
- To evaluate the role of multidetector computed tomography (MDCT) and colour flow imaging (USG) in aiding treatment planning in peripheral arterial diseases.

3. Diagnostic Vascular Modalities in the Lower Extremities Pad

In patients with suspected lower extremity PAD based upon the history and physical examination (e.g. intermittent claudication, ischemic ulcer, gangrene) or in patients with risk factors for vascular disease (e.g. older age, smoking, diabetes mellitus), non-invasive tests are performed to confirm the clinical diagnosis and to further define the level and extent of obstruction [6].

Technique	*Application*	*Limitations*
DSA	Gold-standard for PVD in elective and emergency situations; both *diagnostic* and *therapeutic*	Invasive, ionizing, contrast safety, sedation, luminal imaging only
Duplex USG	Traditional first-line investigation for diagnostic work-up of elective PVD patients; both diagnostic and functional imaging	Requires expertise, time- consuming, limited field of view, calcification, stents
MRA	Alternative first-line investigation for diagnostic work-up of elective PVD patients	Cost, magnetic safety, contrast safety, claustrophobia, waiting list, calcification, stents
CTA	Promising for diagnostic work-up of elective and emergency PVD presentations	Nontherapeutic in an emergency, ionizing, contrast,

Role of different imaging techniques in the investigation of PVD

4. Review of literature

Approximately 30 years ago, initial clinical studies concluded that Colour flow imaging (USG) could be used as a non-invasive test in the diagnosis of PAD of the lowerextremities [7].

Kohler TR at al‘ study (1987) shows that CA could successfully be replaced byDoppler US i.e. colour flow imaging. As in their study duplex studies and angiograms were evaluated in a blinded fashion. For detecting stenosis that were greater than 50% diameter reducing by angiography, duplex scanning had a sensitivity of 82%, a specificity of 92%, a positive predictive value of 80%, and a negative predictive value of 93%[8].

Leiner T at al‘ in 2005 compared Contrast enhanced MRA with Dopplerultrasonography in patients with PAD and they found sensitivity and specificity values were statistically different for Colour flow imaging (USG) (76% and 93%) and MRA (84% and 97%) when compared to eachother [9].

Bueno et al‘ in 2010 in their prospective study (who examined 1720 segments on 40patients) the utility of Doppler US and MRA was evaluated by using CA as reference point. When the detection of stenosis ≥50% was taken as the sole criterion, sensitivity and specificity values were found to be 81.4% and /99% for Colour flow imaging (USG), and 91 and 99% for MRA. Also they observed that the detection oftotal occlusion sensitivity and specificity values are 90% and /97% for Doppler US, and 95.4% and 98% for MRA [10].

Rubin GD at al‘ in 2001 assessed the patterns of lower extremity arterial inflow andrunoff opacification with four-channel multi-detector row computed tomographic (CT) angiography in symptomatic patients of PAD and reliably depicted the arteries of lower extremity inflow and runoff [11].

Ofer A, Nitecki SS , Linn S , et al‘ in 2003 in their prospective comparison study withintra-arterial digital subtraction angiography Multidetector CT angiography of peripheral vascular disease concluded that Multidetector CT angiography is an accurate, noninvasive technique for the imaging of peripheral vascular disease with a sensitivity of 90.9% and a specificity of 92.4% [12]

Catalano Cat al‘ in 2004 compared multi-detector row spiral computed tomographic(CT) angiography with digital subtraction angiography (DSA) in evaluation of the infrarenal aorta and lower-extremity arterial system. They observed that sensitivity, specificity, and accuracy, based on a consensus reading of multi-detector row CT angiograms, were 96%, 93%, and 94%, respectively [13].

Albrecht, FoertE at al‘ in 2007 prospectively compare CT angiography (CTA)performed on a 16-MDCT scanner and digital subtraction angiography (DSA) in patients with peripheral arterial disease and observed sensitivity and specificity for the detection of hemodynamically relevant (> 50%) lesions was 93.3% and 96.5% for observer 1 and 90.1% and 95.6% for observer 2. Also they assessed collaterals, were seen at 150 arterial levels on DSA compared with 97 and 92 levels on CTA ($p < 0.05$, both observers)[14].

Met R , Bipat S , Legemate DA at al‘ in 2009 reviewed and metanalysed thedifferent previous studies to evaluate diagnostic performance of computed tomography angiography in peripheral arterial disease and concluded that it is the more reliable diagnostic modality in assessment of presence and extent of PAD in patients with intermittent claudication [15].

Cernic S, PozziMucelli F at al‘, in 2009 studied the potential of 64-row multislicecomputed tomography (CT) versus digital subtraction angiography (DSA) in detecting significant lesions of lower-extremity inflow and runoff arteries. Compared with DSA, they observed CT angiography yielded 97.2% sensitivity, 97%specificity,%

positive predictive value, 98.9% negative predictive value, 97.1% diagnostic accuracy and 95.4% concordance on the degree ofstenosis [16].

ShareghiS ,Gopal A , Gul K , et al in their study (2010) ―Diagnostic accuracy of 64multidetector computed tomographic angiography in peripheral vascular diseases‖, demonstrates excellent diagnostic accuracy of 64 MDCT in the detection of hemodynamically significant disease of the lower extremities[17]. More segments are visualized using 64 MDCT than DSA, allowing more complete visualization of the vascular tree. Hence, concluded that, CT angiography should be considered in the diagnostic evaluation of symptomatic patients with peripheral vascular disease.

Napoli at al'studieddiagnostic performance and effect on therapeutic management of 64- section computed tomographic (CT) angiography in the assessment of steno-occlusive disease in patients with peripheral arterial disease (PAD), with conventional digital subtraction angiography (DSA) and observed excellentdiagnostic performance of 64 slice MDCT, thus effectively guiding vascular surgeons for therapeutic decision making in PAD [18].

Kayhan.A et al in 2012 compared colour flow imaging (Doppler ultrasonography)and MDCT angiography in patients with clinical symptoms of peripheral arterial disease and concluded that MDCT angiography is more effective in detecting stenotic or obstructed arteries than colour flow imaging (Doppler ultrasonography) [19].

PelinSeherOztekin, AlperSonmez at al, in 2013 compared 64-detector multi-slice CT angiography (MDCTA) and digital subtraction angiography (DSA) in PAD and concluded that MDCTA is significantly compatible with DSA method in the evaluation of peripheral arterial diseases and can be an alternative to DSA [20].

5. Material and Methods

The study was a prospective cross-sectional study. The study included **50 patients** presenting to our hospital with a diagnosis on clinical features of peripheral arterial diseases, during the period of February 2014 to APRIL 2015 and referred for USG & MDCT. This study was approved by the institutional ethical review board.

Inclusion Criteria

- Patients presenting with lower limb intermittent claudication / restpain.
- Patients with gangrene of lowerlimb.
- Patients with absent peripheral pulses in lowerlimb.
- Patients with positive findings on colour flow imaging(USG).
- Polytrauma patients withsuspectedacute arterial injuryinlowerlimb.

Exclusion Criteria

- Patients not consenting for thestudy
- Pregnancy (Risk vs benefit ratio to be assessed)
- Patients with upper limb affection.
- Patients with deranged renal function test (serum creatinine>1.4mg/dl).

Methodology

After taking an **informed written consent** and confirming the patient conformed to **inclusion & exclusion criteria** as described above, a brief **history** was taken from each patient regarding symptomatology and duration of disease.A focused **clinical examination** with the aid of the referring physician was undertaken as regards to severity and extent of involvement of the disease. Details of other investigations done and treatment taken hitherto were also recorded.

CT Peripheral Angiography: Patients underwent Computed Tomographic peripheral angiography (MDCTA) on a **"Brilliance"** 64 slice CT scanner by Philips scanner (Philips Medical Systems, Netherlands) with additional contrast enhanced CT acquired. Plain CT Acquisition is done from the level of lower abdomen infrarenal aorta till ankle or toe if required, scans were performed at 120 kV, 200 mAs in all patients irrespective of Body Mass. A nominal slice width of 5mm and detector collimation of 0.625 mm was kept. A pitch of 1.172 and a gantry rotation time of 0.75 s were set. The resulting scan durations were between 10 to 15 seconds, during which patients were requested to hold their breath. CT angiography performed by injecting 100-110 ml of contrast medium (Iohexol 300mg%v/w) intravenously at a flow rate of 4.5-5 ml/sec with the aid of pressure injector (Mallinckrodt). Arterial phase was taken at an interval of 18-22 sec from the time of contrast injection. Venous phase was taken at an interval of 60-65 sec from the time of contrast injection. Both phases were taken using 1 mm slice thickness.Overlapping reconstruction was performed with a slice thickness of 1 mm at 1 mm intervals. 3D reconstruction with thin planar (1mm) MPR was performed in coronal and sagittal planes. The images were viewed on a TeraRecon workstation capable of viewing source axial images and 3D imaging software tools.

Colour flow imaging (USG):-Then patients were scanned under **TOSHIBA XARIO** USG machine which can combine a real time B mode imaging system with pulsed and continuous wave Doppler facilities together with the availability of colour coding of signals.Patients were instructed to fast for 6 h prior to examination and avoid eating colonic gas forming food..Patients were examined in the supine position. Beginning at the aortic bifurcation, a.3.5 MHz probe was used to examine the aorta, common, and external iliacarteries.A 7.5 MHz probe was sometimes used in well prepared 4 thin patients.In assessing the vessel of interest, the vessel was initially found in B-mode in the axial plane in order to visualize the lumen and the wall of the vessel. Then, the whole vessel was scanned in axial and longitudinal planes by colour-coded duplex followed by spectral tracing of the flow at any suspicious region. A segment was considered as normal when the normal triphasic velocity profile with late diastolic reversal was detected.

Criteria for STENOSIS on Colour flow imaging-

- Significant > 50% narrowing
- Jet / mosaic / turbulence
- Spectral broadening Harsh audio signal

- Increased diastolic velocity > 80%

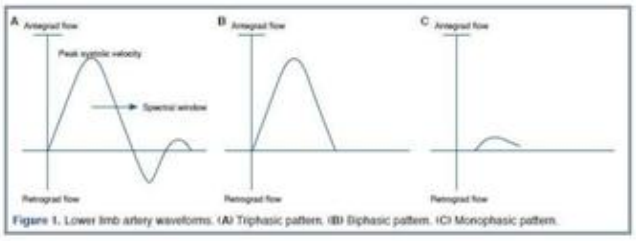
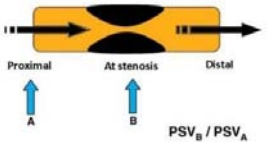


Figure 1. Lower limb artery waveforms. (A) Triphasic pattern. (B) Biphasic pattern. (C) Monophasic pattern.

Grade of stenosis	PSV ratio
0-49%	1.5-2
50%-99%	2.1-4.1
PSV ratio >2.4 ~ considered as stenosis > 50%	



Stenosis was noted when a prestenotic, low velocity, monophasic flow pattern was detected in the proximal vessel segment. A segment with no flow signal was noted asoccluded.

Data analysis

The lower limb arterial system was divided into 3 anatomical regions i.e. aorto-iliac region, femoro-popliteal region &crural regions & 11 anatomical segments as follows:

Infra-renal aorta, common iliac arteries(CIA), external iliac arteries (EIA), internal iliac arteries(EIA), common femoral arteries(CFA), Superficial femoral artery(SFA), Deep femoral artery (DFA), popliteal artery (POP A), anterior tibial artery(ATA), posterior tibial artery(PTA), dorsalispedis artery (DPA).

Each and every anatomical segment of the arterial tree was assigned a grade for the disease extent using a five point ordinal scale:0= Normal,1= Mild stenosis (1–49% diameter reduction), 2= Moderate stenosis (50–74% diameter reduction), 3= Severe stenosis (75–99% diameter reduction), 4= Occlusion.

These grades were given for all arterial segments as evaluated in two techniques; multi-detector row CT angiography (MDCT), colour flow imaging ultrasonography. For all arterial segments the degree of stenosis was measured by dividing the minimal vessel luminal diameter with in this segment by the maximal observed luminaldiameter.Multi-detector row CT angiography and Doppler findings were compared for each arterialsegment.For all practical purpose to analyse the data we had divided the grades of stenosis into ***hemodynamically significant*** which includes 2, 3, 4 ***&hemodynamically non-significant***which includes grade 0, 1. Further we had analyzed these two as mild (hemodynamicallynon significant), severe (hemodynamically significant).

Observation and results -A total number of 50 patients were included in the study. The patients were referred to colour flow imaging (USG) after their local clinical examination, for detecting the exact grade stenosis & extent of involvement of lower limb arterial system.

1) **AgeGroup**- The patients were divided on the basis of age group. Patients (n = 29) were found in the age group of **≤50 yrs**. All patients with trauma are included in it. 21 patients were included in **> 50 YRS** group. The mean age group was 47.04 years, with the range being 12 to 80 years.
2) SexGroup - 36 Patients were male & 14 patients were female. Hence 72 % male distribution is seen in our study group.

Table 1: Demographic characteristics

Variable		*Frequency*	*Percent*
Sex	*Female*	14	28
	Male	36	72
Age	*≤50 yrs*	29	58
	> 50 yrs	21	42
Smoking	*Yes*	21	42
	No	29	58

3) **Risk factors**

Table 2: Risk factors distribution

Variable		*Frequency*	*Percent*
Smoking	Yes	21	42%
	No	29	58%
Diabetes mellitus	Yes	20	40%
	No	30	60%
Hypertension	Yes	18	36%
	No	32	64%
Lipid abnormality	Yes	18	36%
	No	32	64%

4) **Symptoms:** 35 patients were presented with claudication with 18 of them were having intermittent claudication. 12 patients were had rest pain. 14 patients were asymptomatic but referred by clinician‘s i/v/o absent peripheral pulse, to evaluate the arterial system. As our hospital is the one of the biggest trauma centre in the country, we had included poly trauma cases (9 patients) which specifically includes trauma to lower limb for evaluation of arterialanatomy.

Table 3: Distribution of symptoms

Variable		*Frequency*	*%*
Claudication	1)Yes	35	70
	2)No	15	30
Pain at rest	1)Yes	12	24
	2)No	38	76
Trauma to lower limb	1)Yes	9	18
	2)No	41	82
Symptom status	Asymptomatic	14	28
	Symptomatic	36	72

Regionsaffected

Crural region was the most affected region (62%). Followed by femoro-popliteal & aorto-illiac region consecutively.

Table 4: Distribution of Segmental variation

Variable		Frequency	Percent
Aorto-iliac region	Yes	27	54
	No	23	46
Femoro-popliteal region	Yes	28	56
	No	22	44
Crural region	Yes	31	62
	No	19	38
Collaterals	Yes	25	50
	No	25	50

I.Collateal circulation

Collaterals were best seen by MDCT in 25 (61%) patients out of 41 non-trauma patients. This depicts the efficiency of MDCT in evaluation of collateral circulation.

Table 5: Association between Infrarenal aorta by USG and Infrarenal aorta by MDCT

		Infrarenal aorta by MDCT		
		Hemodynamically NON Significant	*Hemodynamically Significant*	
Hemodynamically NON Significant By USG	No.	28	3	31
	%	90.3	9.7	100
Hemodynamically Significant By USG	No.	0	4	4
	%	0	100	100
Total	No.	28	7	35
	%	80	20	100

Out of 35 patients USG could detect only 4hemodynamically significant patients; while MDCT could detect 7 hemodynamically significant patients out of 35. Hence it is evident that MDCT could visualize and accurate result than USG. The association was statistically significant. *($\chi 2=12.860$ p- value<0.001)*

Table 6: Association between Right CIA by USG and Right CIA by MDCT

		Right CIA by MDCT		
		Hemodynamically NON Significant	*Hemodynamically Significant*	
Hemodynamically NON Significant by USG	No.	35	6	41
	%	85.4	14.6	100
Hemodynamically Significant by USG	No.	0	5	5
	%	0	100	100
Total	No.	35	11	46
	%	76.1	23.9	100

The association was statistically significant. *($\chi 2=17.894$ p-value<0.001)*

Table 7 Association between Left CIA by USG and Left CIA by MDCT

		Left CIA by MDCT		
		Hemodynamically NON Significant	*Hemodynamically Significant*	
Hemodynamically NON Significant by USG	No.	35	6	41
	%	85.4	14.6	100
Hemodynamically Significant by USG	No.	0	4	4
	%	0	100	100
Total	No.	35	10	45
	%	77.8	22.2	100

The association was statistically significant. *($\chi 2=15.366$,p-value<0.001)*

Table 8: Association between Right EIA by USG and Right EIA by MDCT

		Right EIA by MDCT		
		Hemodynamically NON Significant	Hemodynamically Significant	
Hemodynamically NON Significant by USG	No.	39	3	42
	%	92.9	7.1	100
Hemodynamically Significant by USG	No.	2	5	7
	%	28.6	71.4	100
Total	No.	41	8	49
	%	83.7	16.3	100

The association was statistically significant. *($\chi 2=18.151$,p-value<0.001)*

Table 9: Association between Left EIA by USG and Left EIA by MDCT

		Left EIA by MDCT		
		Hemodynamically NON Significant	Hemodynamically Significant	
Hemodynamically NON Significant by USG	No.	43	2	45
	%	95.6	4.4	100
Hemodynamically Significant by USG	No.	2	3	5
	%	40	60	100
Total	No.	45	5	50
	%	90	10	100

Out of 50 patients USG could detect 5 hemodynamically significant patients; while MDCT could also detect 5 hemodynamically significant patients out of 45. The association was not statistically significant. *($\chi 2=18.151$,p-value<0.001)*

Table 10: Association between Right IIA by USG and Right IIA by MDCT

		Right IIA by MDCT		
		Hemodynamically NON Significant	Hemodynamically Significant	
Hemodynamically NON Significant by USG	No.	32	7	39
	%	82.1	17.9	100
Hemodynamically Significant by USG	No.	0	2	2
	%	0	100	100
Total	No.	32	9	41
	%	78	22	100

The association was not statistically significant. *($\chi 2=3.454$,p- value<0.001)*

Table 11: Association between Left IIA by USG and Left IIA by MDCT

		Left IIA by MDCT		
		Hemodynamically NON Significant	Hemodynamically Significant	
Hemodynamically NON Significant by USG	No.	32	4	36
	%	88.9	11.1	100
Hemodynamically Significant by USG	No.	0	4	4
	%	0	100	100
Total	No.	32	8	40
	%	80	20	100

The association was statistically significant. *($\chi 2=12.656$,p-value<0.001)*

Table12: Association between Right CFA by USG and Right CFA by MDCT

		Right CFA by MDCT		
		Hemodynamically NON Significant	Hemodynamically Significant	
Hemodynamically Non Significant by USG	No.	35	3	38
	%	92.1	7.9	100
Hemodynamically Significantby USG	No.	0	12	12
	%	0	100	100
Total	No.	35	15	50
	%	70	30	100

The association was statistically significant. *($\chi 2=32.587$,p-value<0.001)*

Table 13: Association between Left CFA by USG and Left CFA by MDCT

		Left CFA by MDCT		
		Hemodynamically NON Significant	Hemodynamically Significant	
Hemodynamically NON Significant by USG	No.	41	2	43
	%	95.3	4.7	100
Hemodynamically Significant by USG	No.	1	6	7
	%	14.3	85.7	100
Total	No.	42	8	50
	%	84	16	100

The association was statistically significant. *($\chi 2=23.711$,p-value<0.001)*

Table 14: Association between Right SFA by USG and Right SFA by MDCT

		Right SFA by MDCT		
		Hemodynamically NON Significant	Hemodynamically Significant	
Hemodynamically NON Significant by USG	No.	34	2	36
	%	94.4	5.6	100
Hemodynamically Significant by USG	No.	0	14	14
	%	0	100	100
Total	No.	34	16	50
	%	68	32	100

The association was statistically significant. *($\chi 2=37.093$,p-value<0.001)*

Table 15: Association between Left SFA by USG and Left SFA by MDCT

		Left SFA by MDCT		
		Hemodynamically NON Significant	Hemodynamically Significant	
Hemodynamically NON Significant by USG	No.	40	3	43
	%	93	7	100
Hemodynamically Significant by USG	No.	0	7	7
	%	0	100	100
Total	No.	40	10	50
	%	80	20	100

The association was statistically significant. *($\chi 2=27.004$,p-value<0.001)*

Table 16: Association between Right DFA by USG and Right DFA by MDCT

		Right DFA by MDCT		
		Hemodynamically NON Significant	Hemodynamically Significant	
Hemodynamically NON Significant by USG	No.	42	1	43
	%	97.7	2.3	100
Hemodynamically Significant by USG	No.	1	5	6
	%	16.7	83.3	100
Total	No.	43	6	49
	%	87.8	12.2	100

The association was not statistically significant. *($\chi 2=25.058$,p-value>0.001)*

Table 17: Association between Left DFA by USG and Left DFA by MDCT

		Left DFA by MDCT		
		Hemodynamically NON Significant	Hemodynamically Significant	
Hemodynamically NON Significant by USG	No.	39	3	42
	%	92.2	7.1	100
Hemodynamically Significant by USG	No.	0	5	5
	%	0	100	100
Total	No.	39	8	47
	%	83	17	100

The association was statistically significant. *($\chi 2=21.009$,p-value<0.001)*

Table 18: Association between Right POP A by USG and Right POP A by MDCT

		Right POP ART by MDCT		
		Hemodynamically NON Significant	Hemodynamically Significant	
Hemodynamically NON Significant by USG	No.	34	2	36
	%	94.4	5.6	100
Hemodynamically Significant by USG	No.	0	12	12
	%	0	100	100
Total	No.	34	14	48
	%	70.8	29.2	100

The association was statistically significant. *($\chi 2=34.420$,p-value<0.001)*

Table 19: Association between Left POP A by USG and Left POP A by MDCT

		Left POP ART by MDCT		
		Hemodynamically NON Significant	Hemodynamically Significant	
Hemodynamically NON Significant by USG	No.	36	3	39
	%	92.3	7.7	100
Hemodynamically Significant by USG	No.	0	10	10
	%	0	100	100
Total	No.	36	13	49
	%	73.5	26.5	100

The association was statistically significant. *($\chi 2=21.009$,p-value<0.001)*

Table 20: Association between Right ATA by USG and Right ATA by MDCT

		Right ATA by MDCT		
		Hemodynamically NON Significant	Hemodynamically Significant	
Hemodynamically NON Significant by USG	No.	27	9	36
	%	75	25	100
Hemodynamically Significant by USG	No.	0	12	12
	%	0	100	100
Total	No.	27	21	48
	%	56.3	43.8	100

The association was statistically significant. *($\chi 2=17.637$,p-value<0.001)*

Table 21: Association between Left ATA by USG and Left ATA by MDCT

		Left ATA by MDCT		
		Hemodynamically NON Significant	Hemodynamically Significant	
Hemodynamically NON Significant by USG	No.	35	3	38
	%	92.1	7.9	100
Hemodynamically Significant by USG	No.	1	10	11
	%	9.1	90.9	100
Total	No.	36	13	49
	%	73.5	26.5	100

The association was statistically significant. *($\chi 2=26.052$,p-value<0.001)*

Table 22: Association between Right PTA by USG and Right PTA by MDCT

		Right PTA by MDCT		
		Hemodynamically NON Significant	Hemodynamically Significant	
Hemodynamically NON Significant by USG	No.	29	6	35
	%	74.5	33.3	100
Hemodynamically Significant by USG	No.	0	12	12
	%	0	100	100
Total	No.	29	18	47
	%	61.7	38.3	100

The association was statistically significant. *($\chi 2=22.574$,p-value<0.001)*

Table 23: Association between Left PTA by USG and Left PTA by MDCT

		Left PTA by MDCT		
		Hemodynamically NON Significant	Hemodynamically Significant	
Hemodynamically NON Significant by USG	No.	35	3	38
	%	92.1	7.9	100
Hemodynamically Significant by USG	No.	1	9	10
	%	0	100	100
Total	No.	36	12	48
	%	75	25	100

The association was statistically significant. *($\chi 2=24.253$,p-value<0.001)*

Table 24: Association between Right DPA by USG and Right DPA by MDCT

		Right DPA by MDCT		
		Hemodynamically NON Significant	Hemodynamically Significant	
Hemodynamically NON Significant by USG	No.	36	3	39
	%	92.3	7.7	100
HemodynamicallySignificant by USG	No.	0	8	8
	%	0	100	100
Total	No.	36	11	47
	%	76.6	23.4	100

The association was statistically significant. *($\chi 2=26.613$,p-value<0.001)*

Table 25: Association between Left DPA by USG and Left DPA by MDCT

		Left DPA by MDCT		
		Hemodynamically NON Significant	Hemodynamically Significant	
Hemodynamically NON Significant by USG	No.	41	3	44
	%	93.2	6.8	100
HemodynamicallySignificant by USG	No.	1	5	6
	%	16.7	83.3	100
Total	No.	42	8	50
	%	84	16	100

The association was statistically significant. *($\chi 2=22.574$,p-value<0.001)*

6. Discussion

Common risk factors for the PAD includes increasing age, smoking, hypertension, diabetic mellitus, and dyslipidemia. Our study shows consistent association of these risk factors with PAD. In our study we found 21 patients were belongs to more than 50 yrs age group compared to 15 cases in less than or equal to 50 yrs age group with mean age was 47.4. Thus our study concludes that distribution of disease increases in elderly population. These results are similar as with study done by Selvin E, Erlinger TP atal [21]in , where they found PAD prevalence increases dramatically with age&presents as 14.3 % in > 70 yrs of age.

We found 42 % of smokers in our study population, concluding the smoking is one of the primary risk factor in PAD development & progression. Several studies have shown that smoking cessation leads to significant decrease

in the prevalence of PAD (20, 104). Cole CW, atalin 1993 in their study where they compared with men who had never smoked the relative risk was 7 for ex-smokers and 16 for current smokers ($p < 0.001$). The relative risk increased directly with the lifetime number ofcigarettes smoked, the chi-square test for trend being highly significant ($p < 0.001$) [22].

In our study 36 % of patients were hypertensive. Hypertension is also positively associated with PAD (Selvin and Erlinger 2004) as shown in the NationalHealth and Nutrition Survey (NHANES) data. In this study, 2174 participants >40 years of age from the 1999–2000 National Health and Nutrition Examination Survey were included. PAD (ABI <0.9 in either leg) was prevalent in 4.3% of patients. Among those >70 years of age, the prevalence was 14.5%. Current smoking (OR 4.46, 95% CI 2.25–8.84), diabetes (OR 2.71, 95% CI 1.03–7.12), hypertension (OR1.75, 95% CI 0.97–3.13), hypercholesterolemia (OR 1.68, 95% CI 1.09–2.57), and low kidney function (OR 2.00, 95% CI 1.08–3.70) were positively associated with prevalent PAD [23].

In our study most common presenting symptom was claudication (70)%. Other studies also shown that claudication is the most common symptom in the patients who were having PAD [25].The most common region affected we found was crural region 62 %, followed by the femoro-popliteal & aorto-iliac regions.

Although colour flow imaging (USG) is considered as the first choice modality and screening method in assessing mild PAD it has several limitations. Obesity impairs examining aortoiliac and femoral regions, abdominal distention increases the difficulty of examining iliac vascular structures, and it is an operator dependent imaging modality. Furthermore, colour flow imaging (USG) struggles to assess sequential multi-segmental stenosis. The sensitivity of colour flow imaging (USG) in detection of one segment stenosis is high, but it is decreased when diagnosing multi-segmental disease because stenosis in proximal arterial segments decreases peak systolic velocities and reduces post stenotic and post-occlusive flows [24].

In recent studies, it has been shown that the median sensitivity and specificity of colour flow imaging for the detection of > 50% stenosis for the whole leg are 88% and 96%, respectively. For the detection of occlusion in whole leg, colour flow imaging (USG) had a median sensitivity of 90% and median specificity of 99% [24,25].

MDCTA is increasingly being used as a promising minimally invasive tool for the evaluation of patients with PAD. Previous studies have been performed with 4 and 16-row MDCTA in which the diagnostic accuracy of MDCTA for detection of>50% stenosis and occlusion in whole leg has been searched. The median sensitivity and specificity values have been found to be 91% and 91% for>50% stenosis and 97% and 99.6% for occlusion, respectively [26]. In our study, in which 64-row MDCTA was performed, sensitivity and specificity values could not be calculated because DSA was not performed aswell. Also MDCT angiography is feasible, accurate, and reliable in the assessment of peripheral arterial bypass grafts and detection of graft-related complications, including stenosis, aneurysmal changes, and arteriovenous fistulas.

William et al. [27] made a study in 2005 to compare contrast enhanced MRA and MDCT angiography. They found no statistically significant difference between 3D contrast-enhanced MR angiography and MDCT angiography in the detection of hemodynamically significant arterial stenosis of the aorto-iliac and renal arteries. Yet, the patients‘acceptance was better for MDCT angiography. It took shorter time and caused less noise.

The diagnostic performance of MDCTA in subdivisions of the lower extremity has been tested, and studies reported a lower sensitivity and specificity for the infra- popliteal tract than for the aortoiliac and the femoro-popliteal tracts, although these differences were not statistically significant .In the study with a lower accuracy rate, the complete infra-popliteal tract was not depicted because a 2- section CT scanner was used . The most encouraging results were reported by Willmann et al. who used a 16-section CT scanner [28]. In a meta-analysis, a sensitivity of 92% and specificity of 93% were reported for lower extremity arterial disease with >50% stenosis. The researchers also stated that the diagnostic performance of MDCTA was almost as good as that of DSA

We found extra information like extra luminal pathology by MDCT than colour flow imaging (USG). Also in our study we had concluded that MDCT is more accurate in accessing multilevel stenosis, bilateral limb involvement & length of stenosis. In evaluation of collateral circulation we found that 25 (61 %) patients out of 41 cases we completely evaluated thecollaterals.

In our study we compared the imaging findings of colour flow imaging & MDCTA in different arterial segments independently. We found that the overall MDCT detects significantly more severe cases i.e. hemodynamically significant cases thus guided more in the management of the patients with PAD. Thus, We could accurately depict the severe cases to guide the surgeon‘s knife for the betterment ofpatients.Also by grading the hemodynamicallynon significant cases, we had definitely aided in the treatment plan for those patient who required lifestyle modification, smoking cessation, dyslipidemia management.

In infra-popliteal segments we found that the MDCT contrast run off is not good in few cases in those we found USG was better to assess the flow & severity of disease but it could not be compared as all these segments were evaluated independently.Overall, analysis of our results showed that when colour flow imaging (USG) and MDCTA are compared, MDCTA detects more stenotic or occluded arteries in supra-popliteal, infra-popliteal, and whole leg comparisons.

Our infra-popliteal data differ from the results for MDCTA in infra-popliteal regions reported above, in which USG is as good or better than MDCTA. However, these data represent indirect comparisons between different patient groups

looking independently at DUS or MDCTA to determine sensitivity and specificity of testing.

Our study, conversely, performs a direct comparison between the two imaging modalities on the same patient population. In this study, our main limitation was that colour flow imaging and MDCTA findings were not compared with DSA, which is considered to be the gold standard technique in detecting lower extremity PAOD.Therefore, our results may underestimate the percentages of arteries with lesions that are actually detectable in patients withPAD.

7. Summary & Conclusion

- The totalnumber of patients were studied 50.
- 29 patients were found in the age group of **≤50 yrs**. 21 patients were included in **> 50 YRS** group. The mean age group was 47.04 years, with the range being 12 to 80years.36 (72 %) Patients were male & 14 patients were female.
- 42 % study patients were smokers. 40 % of patients were diabetic. 36 % of patients were hypertensive & same 36 % had lipid abnormalities.
- 35 patients were presented with claudication with 18 of them were having intermittent claudication. 12 patients had rest pain. 14 patients were asymptomatic. As our hospital is the one of the biggest trauma centre in the country, we had included poly trauma cases (9 patients) which specifically includes trauma to lower limb, were referred for evaluation of arterial anatomy.
- Among all lower limb arterial regions, crural region was the most affected region (62%), followed by femoro-popliteal & aorto-iliac region consecutively.
- Collaterals were best seen by MDCT in 25 (61%) patients out of 41 non- trauma patients.
- MDCT could visualize and was accurate than USG with statistically significant association in infrarenal aorta and arteries of the bilateral lower limb except for the left IIA, right EIA and right DFA where statistical association was not significant.

7.1 Conclusion

Colour flow imaging ultrasonography can be successfully used in the screening and follow-up of PAD cases of the lower extremities which is a prevalent and serious condition in elderly population. In which the Colour flow imaging (USG) has the advantage of being a non-invasive procedure without the need for contrast agents& absence of ionic radiation.Colour flow imaging (USG) is recommended by the latest guidelines as the first screening modality to be chosen when the ankle brachial index measurement is not available. With its high specificity, especially the demonstration of the absence of a stenosis≥50% using Colour flow imaging (USG) mostly excludes the presence of PAD in the lower limbs.Colour flow imaging ultrasonography was reported to have difficulty in differentiating a 99% stenosis from complete occlusion. In addition, obesity, presence of intestinal gas and limb oedema may complicate the quality imaging of the arteries. Distal arteries are frequently difficult to be imaged due to their small size. Moreover, age related or accelerated vessel wall calcifications easily impair the conduct of the Doppler signals.Although this technique does not allow imaging of the arterial tree as a whole, valuable and quality information on vessel hemodynamics can easily be obtained in the perioperative period.

As compared with digital subtraction angiography (DSA), MDCT angiography is highly accurate ,faster (12 minutes vs 58 minutes) and better tolerated (referred pain, 1.9% vs 67%) in the diagnosis and staging of peripheralarterial disease (PAD). Beyond the stenosis evaluation and staging of PAD, peripheral MDCT angiography is a valid, strong, and reliable technique which guide to select the most correct therapeutic plan (endovascular or surgical). We concluded that MDCT angiography is feasible, accurate, and reliable in the assessment of peripheral arterial bypass grafts and detection of graft-related complications, including stenosis, aneurismal changes, and arteriovenous fistulas.

Only major disadvantage of MDCTA was radiation dose, though it was 2-3 folds less than that to conventional angiography.

Overall, analysis of our results showed that when colour flow imaging USG and MDCTA are compared, MDCTA detects more stenotic or occluded arteries in supra-popliteal, infrapopliteal, whole leg comparisons & excellent diagnostic performence. Simultaneusly, our infrapopliteal data differ from the results for MDCTA in infra-popliteal regions reported above, in which colour flow imaging (USG) is as good or better than MDCTA. However, these data represent indirect comparisons between different patient groups looking independently at colour flow imaging (USG) or MDCTA to determine sensitivity and specificity of testing.

Our study reveals excellent diagnostic performance of 64-section CT angiography and strong clinical relevance in a large consecutive series of patients with clinical symptoms of PAD. In conclusion, colour flow imaging is useful screening tool, however in symptomatic patient for detailed evaluation, MDCTA is a semi-invasive, fast, and accurate alternative to DSA, and we believe MDCTA better detects stenotic or obstructed arteries than colour flow imaging (USG) in patients of PAD.

8. Pictorial Essay

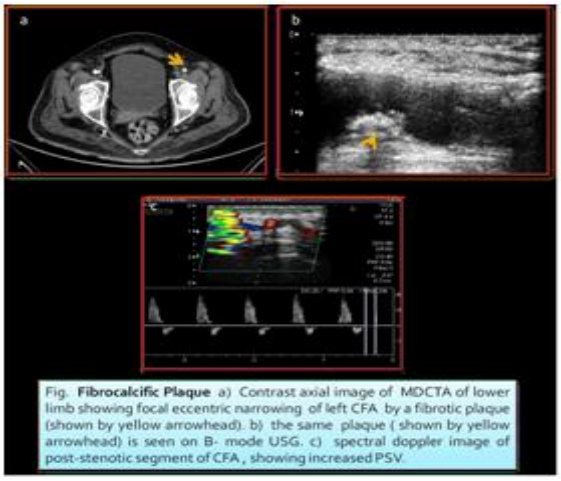


Fig. **Fibrocalcific Plaque** a) Contrast axial image of MDCTA of lower limb showing focal eccentric narrowing of left CFA by a fibrotic plaque (shown by yellow arrowhead). b) the same plaque (shown by yellow arrowhead) is seen on B- mode USG. c) spectral doppler image of post-stenotic segment of CFA , showing increased PSV.

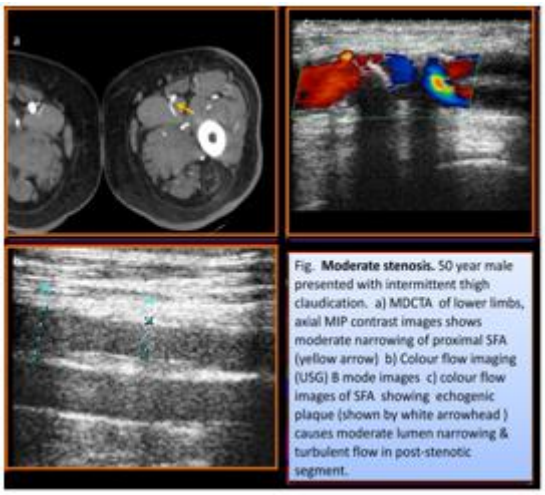


Fig. **Moderate stenosis.** 50 year male presented with intermittent thigh claudication. a) MDCTA of lower limbs, axial MIP contrast images shows moderate narrowing of proximal SFA (yellow arrow) b) Colour flow imaging (USG) B mode images c) colour flow images of SFA showing echogenic plaque (shown by white arrowhead) causes moderate lumen narrowing & turbulent flow in post-stenotic segment.

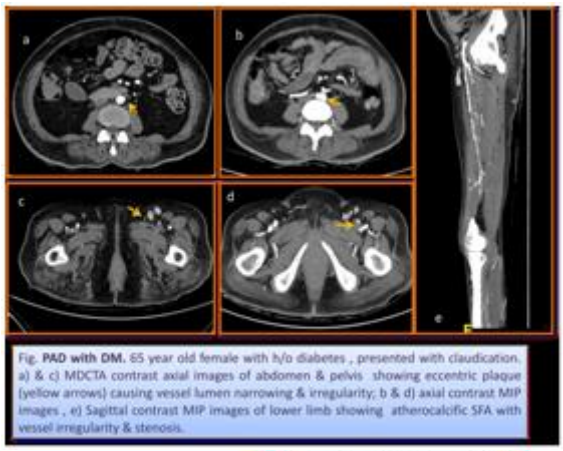


Fig. **PAD with DM.** 65 year old female with h/o diabetes , presented with claudication. a) & c) MDCTA contrast axial images of abdomen & pelvis showing eccentric plaque (yellow arrows) causing vessel lumen narrowing & irregularity; b & d) axial contrast MIP images , e) Sagittal contrast MIP images of lower limb showing atherocalcific SFA with vessel irregularity & stenosis.

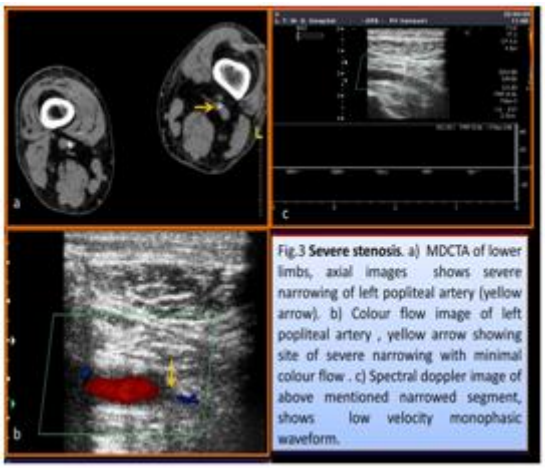


Fig.3 **Severe stenosis.** a) MDCTA of lower limbs, axial images shows severe narrowing of left popliteal artery (yellow arrow). b) Colour flow image of left popliteal artery , yellow arrow showing site of severe narrowing with minimal colour flow . c) Spectral doppler image of above mentioned narrowed segment, shows low velocity monophasic waveform.

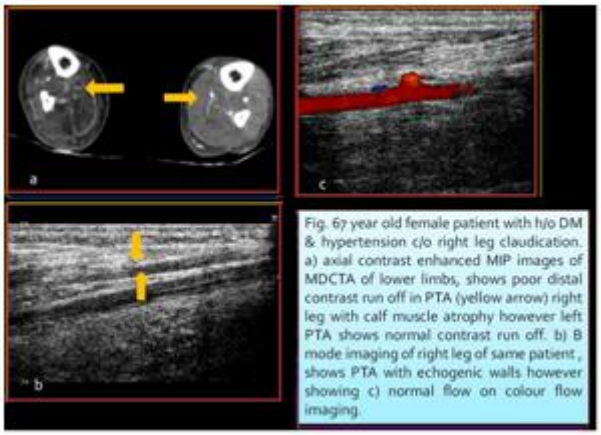


Fig. 67 year old female patient with h/o DM & hypertension c/o right leg claudication. a) axial contrast enhanced MIP images of MDCTA of lower limbs, shows poor distal contrast run off in PTA (yellow arrow) right leg with calf muscle atrophy however left PTA shows normal contrast run off. b) B mode imaging of right leg of same patient , shows PTA with echogenic walls however showing c) normal flow on colour flow imaging.

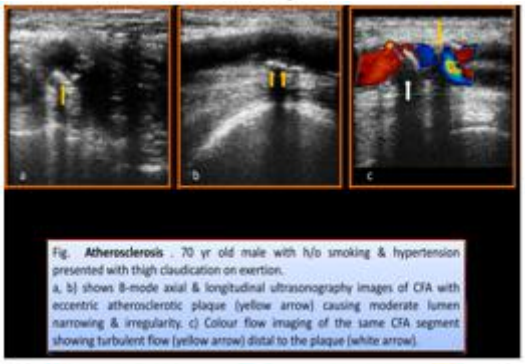


Fig. **Atherosclerosis** . 70 yr old male with h/o smoking & hypertension presented with thigh claudication on exertion.
a, b) shows B-mode axial & longitudinal ultrasonography images of CFA with eccentric atherosclerotic plaque (yellow arrow) causing moderate lumen narrowing & irregularity. c) Colour flow imaging of the same CFA segment showing turbulent flow (yellow arrow) distal to the plaque (white arrow).

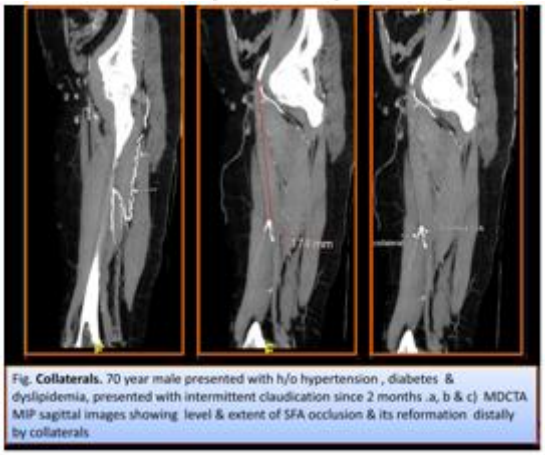


Fig. **Collaterals.** 70 year male presented with h/o hypertension , diabetes & dyslipidemia, presented with intermittent claudication since 2 months .a, b & c) MDCTA MIP sagittal images showing level & extent of SFA occlusion & its reformation distally by collaterals

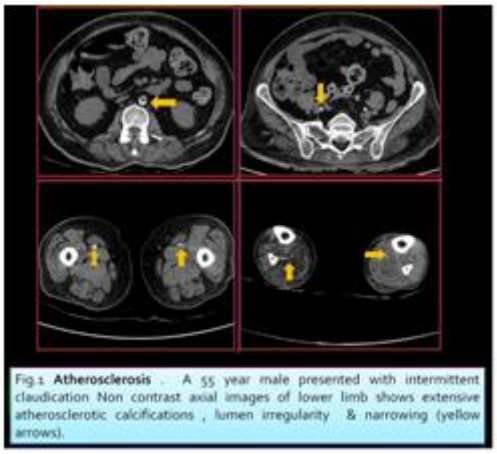


Fig.1 **Atherosclerosis** . A 55 year male presented with intermittent claudication Non contrast axial images of lower limb shows extensive atherosclerotic calcifications , lumen irregularity & narrowing (yellow arrows).

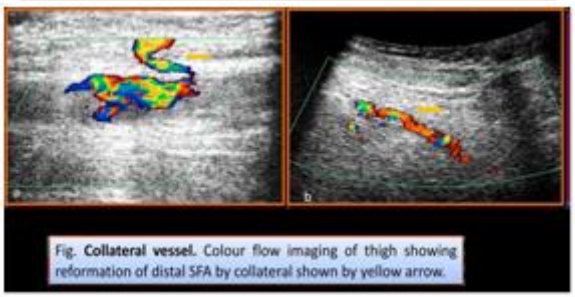


Fig. **Collateral vessel.** Colour flow imaging of thigh showing reformation of distal SFA by collateral shown by yellow arrow.

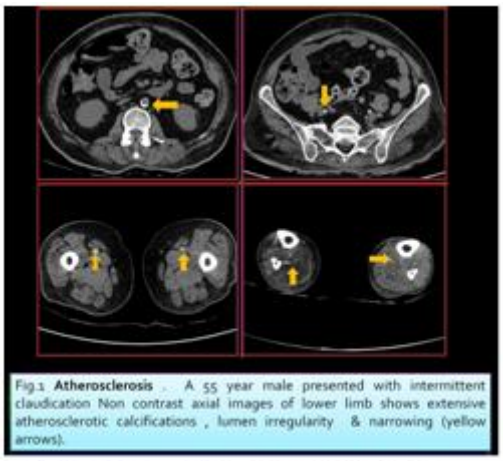


Fig.1 **Atherosclerosis** . A 55 year male presented with intermittent claudication Non contrast axial images of lower limb shows extensive atherosclerotic calcifications , lumen irregularity & narrowing (yellow arrows).

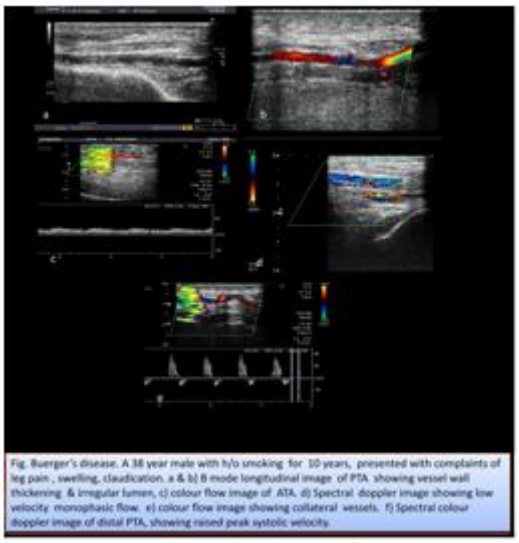


Fig. Buerger's disease. A 38 year male with h/o smoking for 10 years, presented with complaints of leg pain , swelling, claudication. a & b) B mode longitudinal image of PTA showing vessel wall thickening & irregular lumen, c) colour flow image of ATA. d) Spectral doppler image showing low velocity monophasic flow. e) colour flow image showing collateral vessels. f) Spectral colour doppler image of distal PTA, showing raised peak systolic velocity.

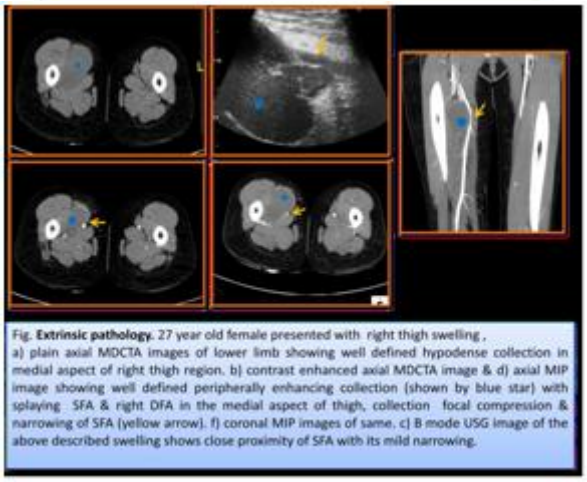


Fig. **Extrinsic pathology.** 27 year old female presented with right thigh swelling , a) plain axial MDCTA images of lower limb showing well defined hypodense collection in medial aspect of right thigh region. b) contrast enhanced axial MDCTA image & d) axial MIP image showing well defined peripherally enhancing collection (shown by blue star) with splaying SFA & right DFA in the medial aspect of thigh, collection focal compression & narrowing of SFA (yellow arrow). f) coronal MIP images of same. c) B mode USG image of the above described swelling shows close proximity of SFA with its mild narrowing.

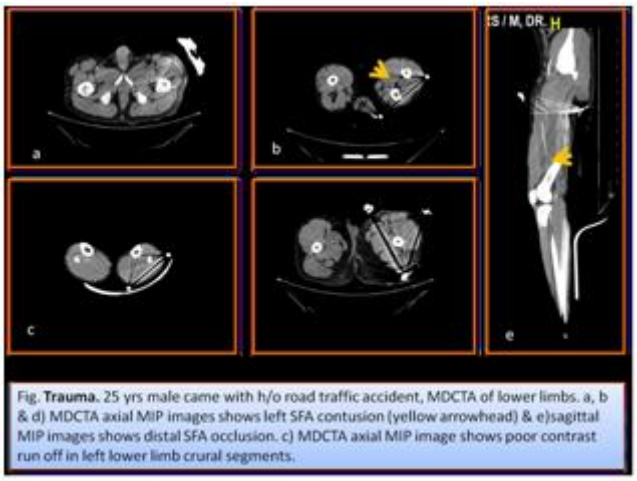


Fig. **Trauma.** 25 yrs male came with h/o road traffic accident, MDCTA of lower limbs. a, b & d) MDCTA axial MIP images shows left SFA contusion (yellow arrowhead) & e)sagittal MIP images shows distal SFA occlusion. c) MDCTA axial MIP image shows poor contrast run off in left lower limb crural segments.

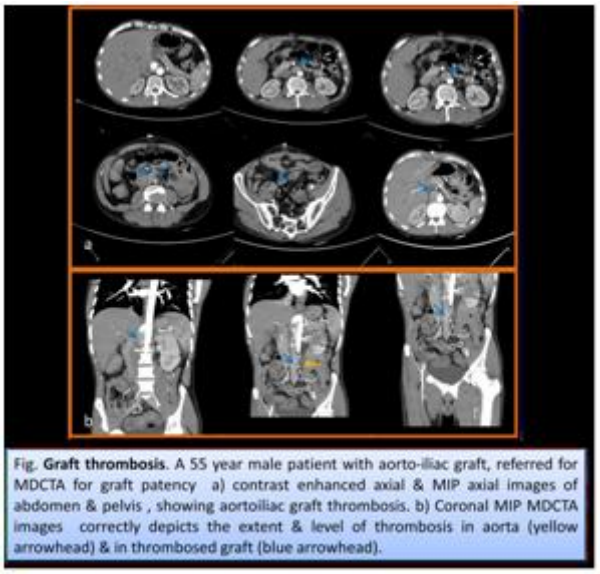


Fig. **Graft thrombosis.** A 55 year male patient with aorto-iliac graft, referred for MDCTA for graft patency a) contrast enhanced axial & MIP axial images of abdomen & pelvis , showing aortoiliac graft thrombosis. b) Coronal MIP MDCTA images correctly depicts the extent & level of thrombosis in aorta (yellow arrowhead) & in thrombosed graft (blue arrowhead).

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